ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5240

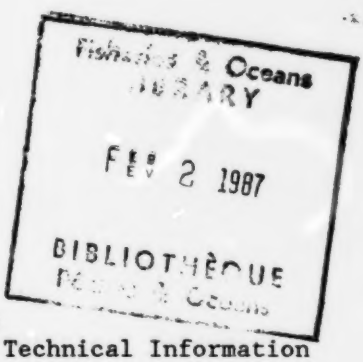
Two species of Chloromyxum (Myxozoa: Myxosporea) in chum salmon, Oncorhynchus keta (Walbaum): taxonomy and life cycle

S. Uruwa and O. Hiroi

Original title: Sak ni Kisei suru Nen'eki Hoshichu Chloromyxum 2 Shu no Bunrui to Seikatsushi

In: Hokkaido Sake-Masu Fukajo Kenkyu Hokoku 40: 11-20, 1986

Original language: Japanese



Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1986

16 typescript page

Secretary of State / Secrétariat d'État

90-02711/

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU BUREAU DES TRADUCTIONS

LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

Translated from - Traduction de	Into - En
Japanese	English

Author - Auteur

Shigehiko URAWA and Osamu HIROI

Title in English or French - Titre anglais ou français

Two Species of Chloromyxum (Myxozoa: Myxosporea) in Chum Salmon, Oncorhynchus keta (Walbaum): Taxonomy and Life Cycle

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)

Sake ni Kisei suru Nen'eki Hoshichu Chloromyxum 2 Shu no Bunrui to Seikatsushi

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.

Hokkaido Sake-Masu Fukajo Kenkyu Hokoku

Reference in English or French - Référence en anglais ou français

Scientific Reports of the Hokkaido Salmon Hatchery

Publisher - Éditeur	DATE OF PUBLICATION / DATE DE PUBLICATION			Page Numbers in original / Numéros des pages dans l'original
–	Year / Année	Volume	Issue No. / Numéro	11-20
Place of Publication / Lieu de publication				Number of typed pages / Nombre de pages dactylographiées
–	1986	–	40	16

Requesting Department / Ministère-Client: DFO

Translation Bureau No. / Notre dossier nº: 2537227

Branch or Division / Direction ou Division: IPB

Translator (Initials) / Traducteur (Initiales): PS

Person requesting / Demandé par: N. Johnson

SEP 15 1986

Your Number / Votre dossier nº: –

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

Date of Request / Date de la demande: 7 August 1986

Canada

SEC 5-111 (84-10)

Secretary of State | Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU | BUREAU DES TRADUCTIONS

Client's No.–N° du client	Department – Ministère	Division/Branch – Division/Direction	City – Ville
–	DFO	IPB	Ottawa
Bureau No.–N° du bureau	Language – Langue	Translator (Initials) – Traducteur (Initiales)	
2537227	Japanese	PS	SEP 15 1986

Two Species of Chloromyxum (Myxozoa: Myxosporea) in Chum Salmon, Oncorhynchus keta (Walbaum): Taxonomy and Life Cycle

by

Shigehiko URAWA* and Osamu HIROI*

Chloromyxum wardi Kudo, 1920 and *C. salvelini* Fujita, 1923 from chum salmon in the Chitose River, Hokkaido, Japan, are described, and their life cycles are speculated. Morphological comparisons with other species of *Chloromyxum* reveal that *C. chitosense* Fujita, 1923 is synonymous with *C. wardi*. Chum salmon fry become infected with both species during their freshwater life, but spore formation does not occur for 2.5 to 4.5 years after seaward migration. Young trophozoites of the parasites are present in the gallbladder of maturing chum salmon that migrate into the coastal waters near their natal river. By the time of spawning spore formation has completed, and mature spores are expelled through the host's intestine into the environment. The observations suggest that spore formation of *C. wardi* and *C. salvelini* in chum salmon is synchronized with host's reproduction by hormones connected with the ripening of the fish host. Prevalences of spores of *C. wardi* and *C. salvelini* in spawning chum salmon are 59.6% and 23.7%, respectively, and decrease over the course of the spawning season. This may be associated with the duration of freshwater life in the fry stage.

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

*Hokkaido Salmon Hatchery, Fisheries Agency, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062 JAPAN.

The protozoan Myxosporidium Chloromyxum parasitizes mainly the gall bladder of freshwater fish. Shulman (1984) described 37 species. Some of these such as C. truttae parasitize trouts and are agent of disease (Bauer et al. 1969). Most reports on Chloromyxum deal with morphology but the ecology remains virtually unknown. Although 5 species were found in the Salmonidae family from Japan (Fujita 1923, 1936), no report at all followed the original descriptions.

We examined the phases of the organisms parasitizing the chum salmon Oncorhynchus keta in the Chitose river and found in the gall bladder 2 species of sporozoa belonging to Chloromyxum. In the present study, we examined and described the morphology of these 2 species of sporozoon, using mainly a scanning electron microscope, and performed a taxonomic reexamination dealing also with known species. We clarified the seasonal variation in appearance rates in chum salmon and discussed the relationship between this parasite and the life history of the host.

Materials and method p. 12

Survey sites and sample fish

The survey sites are shown in Fig. 1. The Chitose river is located in central west Hokkaido. It flows from Lake Shikotsu and meets the Ishikari river. Before emptying into the Ishikari Bay, its course is about 100 km. There is a salmon-trout hatching ground 20 km downstream of Lake Shikotsu. Using a water upwelling, about 25 million chum salmon fry raised for several months are released every year into the Chitose river. The sample fish were 95 chum salmon fry collected with tow nets in April 1982 along the banks of the Chitose river and

Ishikari Bay, 337 parent chum salmon swimming up the Chitose river and caught from September to November 1981 and 1982, and 50 parent chum salmon caught with stationary nets at Atsuta along the coast of the Ishikari Bay in the Sea of Japan. The parasite phases of the chum salmon caught in Atsuta indicated that the fish came from the Chitose river. For the sake of comparison, we also used 40 salmon caught with gill nets in May 1982 in the North Pacific (41-45° N, 156-173° E).

Examination method

After collecting the gall bladders of the salmons, we used some of the bile as smearing specimen and examined the parasites with an optical microscope. The sporozoa obtained were fresh and we measured the various parts of the spores with a micrometer. We also squeezed out polar filaments with 5% KOH, and measured their length. We fixed some of the spores for 30 min with 1% glutaric aldehyde (0.1 M phosphoric acid buffer solution, pH 7.2), washed, dehydrated and dried with a critical point drier. After coating with a vacuum evaporator we examined the spore surfaces, using a scanning electron microscope (Akashi α-10).

Results

Description of the Species

Chloromyxum wardi KUDO, 1920

Host: Chum salmon Oncorhynchus keta (WALBAUM)

Site in host: gall bladder

Trophozoites: We note all kinds of growth stages. The trophozoites having developed spores are 22-31 μm x 19-29 μm in size and contain 5-10 spores in their inside.

Spores: They are made of 2 shells. The spores are almost diamond-shaped in the side view (Fig. 2A), and almost round in the front view (Fig. 2B). The end surface is almost round or diamond-shaped (Fig. 2C). The length is 8.1 (7.7-8.8) μm (average (range) for 25 individuals; omitted hereafter), the width is 7.8 (6.9-9.2) μm and the thickness 8.0 (7.3-8.8) μm. The sutures are largely rectilinear. Rather thin outgrowth lines run in complicated patterns over the surface of the shell from the suture outgrowth. The patterns and numbers differ in all spores. There is no regularity. At the front end of the spore, on the inside there are 4 polar capsules. The polar capsules are elliptic in the side views with a length of 2.7 (2.3-3.2) μm and a width of 2.3 (1.7-3.1) μm. The length of the squeezed out polar filaments is 35.7 (25.5-51.0) μm.

Chloromyxum salvelini Fujita, 1923

Host: Chum salmon Oncorhynchus keta (WALBAUM)

Site of parasite: Gall bladder

Trophozoites: The size of the trophozoites showing advanced development is 23-28 μm x 20-28 μm. On the inside, they form 1-3 (usually 2) spores.

Spores: They are made of 2 shells and show an almost spherical shape (Fig. 3). The length is 12.7 (11.0-15.8) μm, the width 12.7 (10.8-15.0) μm and the thickness 12.7 (10.8-15.8) μm. The suture surface is clear and protrudes from the shell surface. The front part

of the suture is largely curved. Outgrowth lines run in complicated patterns on the surface of the shell. There is no determined mode. The number is however greater than in C. wardi. There are 4 polar capsules, 4.2 (3.1-5.4) µm in length and 3.5 (2.8-3.9) µm wide. The polar filament length is 57.5 (37.6-72.3) µm.

Variations in appearance rates

We showed in Table 1 the appearance rates of the 2 types of Chloromyxum spores by salmon growth stage. No Chloromyxum parasitism was found in the chum salmon fry caught in the river or in the fry that had travelled down the river to the sea. No Chloromyxum was found either in the gall bladder of chum salmon caught in the North Pacific. Likewise, no Chloromyxum spores were noted in parent chum salmon having migrated toward the coast for spawning. However, individuals deemed to be early-period trophozoite Chloromyxum were observed in the gall bladder of 4 of the 50 fishes. We noted C. wardi spores in some pre-spawning parent chum salmons having ascended the Chitose river. The appearance rate was 15.0%. No C. salvelini spores were seen. Yet the appearance rate was 59.6% for C. wardi and 23.7% for C. salvelini among the parent chum salmon immediately after spawning.

We show in Fig. 4 the appearance rates of the 2 species of Chloromyxum among spawning parent chum salmon from September to November 1981 and 1982. Both species were observed in the parent fish at the same period. Later, the appearance rate tended to decline. p. 16

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

Discussion

Classification

Ten species of Chloromyxum are known in the North Pacific Salmo genus (Margolis 1982a). Table 2 compares the morphological characteristics of those and of the 2 species found in the present study. Among the Chloromyxum parasitizing the chum salmon of the Chitose river, a large species identified as C. salvelini was discovered in the gall bladder of the white-spotted char Salvelinus leucomaenis* from Lake Shikotsu by Fujita (1923) and reported by the same. The great characteristic of C. salvelini is that only 1-3 spores are formed in the trophozoites. Meanwhile, the small species was found by Kudo (1920) in the gall bladder of sockeye salmon Oncorhynchus nerka from Alaska. The morphological characteristics agree well with those of the described new species C. wardi, and the present species was identified as C. wardi. It is known that outside Alaska, C. wardi is also distributed in the Soviet Union Kamtchatka area (Konovalov 1971) and parasitizes the humpback salmon O. gorbuscha and the chinook salmon O. tshawytscha (Margolis 1982a). This is the first report with regard to chum salmon. However, C. Chitosense is recorded to be found in the gall bladder of chum salmon from the Chitose river (Fujita 1923) and the parasitization rate is reported to be 40% (Fujita 1937). It is reported that the characteristic of this species is that the shell surface is smooth. No such species was discovered during any period of the present study. C. wardi was observed as a species showing a closely similar appearance rate. Apart from the surface structure of the shell, the morphology

---

*Reported by Fujita as S. kundscha.

of C. chitosense is extremely similar to that of C. wardi. The outgrowth lines of the spore surface are very fine, and depending on the observation conditions, there is much likelihood of not seeing them at all. Since it is hard to believe that this species disappeared from the Chitose river, our judgment is that C. chitosense is synonymous for C. wardi. There are resemblances between the other species listed in Table 2. For instance, all three C. quadriforme, C. oncorhynchi and C. orientale have been found in Masu salmon (sakuramasu) along the Okhotsk coast. As their morphology is extreme by similar, there is a p. 18
strong possibility that they are one same species. Be it as it may, all existing descriptions are based on observations made with optical microscopes, and one cannot say that the description of the minute morphology of the spores is quite satisfactory. One should observe again the morphology of the spores of the various Chloromyxum, using equipment such as electron microscopes, and perform a new taxonomic examination.

Life cycle

Fig. 5 shows a scheme of the life cycle of Chloromyxum parasitizing chum salmon. Although Chloromyxum was not seen to parasitize the gall bladder of chum salmon fry at the stream life period or early pelagic life period, it seems that since both species of parasite are freshwater species, contamination must have occurred at the stream life period of the fry. A few Chloromyxum trophozoites were observed in chum salmon parent fish having returned to the coast for spawning. As the fish mature, the trophozoites become more numerous in the gall bladder, and numerous spores appear in the gall bladder at the

time when the chum salmon swim up the rivers and spawn. Since the chum salmon caught along the Atsuta coast are 3-4 weeks away from swimming up the rivers to mature and spawn, the Chloromyxum has to form spores during the same period. It seems that the spores in the gall bladder are released in the water via the digestive tract of the host, and contaminate the chum salmon fry in the next spring. The contamination process is unknown. It seems that the parasites stay in some intermediate host species as reported about the Myxosporidium Triactinomyxon gyrosalmo (= Myxosoma cerebralis) causing the winding disease among chum salmon, that they winter there and then contaminate the fry.

According to the anadromous period of chum salmon, there are the early group (September-early October), the middle group (early October-mid-November) and the late group (mid-November-December). The appearance rate of Chloromyxum tended to be high in the early group. Among the chum salmon fry released in the Chitose river, those individuals originating from the early group have a relatively long stream life period and we know that most of the other fry swim down to the sea in about 10 days (Mayama 1982, 1983). It seems that the high appearance rate in the early group reflects the long stream life period of the chum salmon fry. The parent chum salmon examined were mainly 4 years old. There were 3- or 5-year-old fish. Yet as we found Chloromyxum spores in all spawning parent fish regardless of the age group, it is evident that Chloromyxum is unaffected by the pelagic life p. 19 period of the host, and that it forms mature spores in accordance with the period in which the chum salmon swim up the rivers to spawn. This seems to be the result of the fact that most Chloromyxum which are a

freshwater species have adjusted to the ecology of chum salmon which live in the sea. We do not know the factors involved in the formation of spores. It is, however, known that Henneguya salminicola which is a freshwater Myxosporidium parasitizing the muscles of chum salmon show after more than 1 year following contamination mature spores in parent fish migrating to spawn in the natal river. Because of this, it seems that there is some action from hormones released by the host (Margolis 1982b). It is known that the nematode Philonema oncorhynchi which parasitizes sockeye salmon during its freshwater life period matures at the time when the host migrates to the natal river to spawn, and it is experimentally certain that the pituitary hormones accelerate the growth of the parasite (Bashirullah and Adams 1983). In the present study, we made a simultaneous analysis of the maturation hormones in the serum of the chum salmon we examined and it was demonstrated that several kinds of sex hormones increase together with the sexual maturity of chum salmon (Hiroi 1982, Ueda et al. 1984). The formation stage of the Chloromyxum spores agreed well with the changes of these sex hormones. It thus seems possible that the hormones related to maturation in the host participate in the maturation of Chloromyxum. One must still clarify the contamination mechanism and the factors involved in the spore formation.

At the close of this article, I wish to thank Dr. Kazuya NAGASAWA of the Hokkaido Fisheries Research Center in Hakodate who revised my report.

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

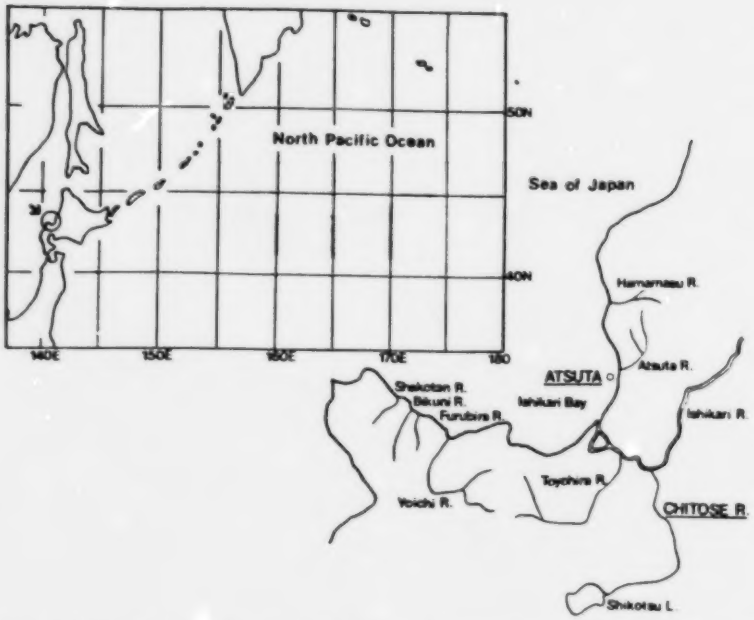


Fig. 1. Maps showing sampling area. Dotted part denotes the sampling areas in the North Pacific Ocean.

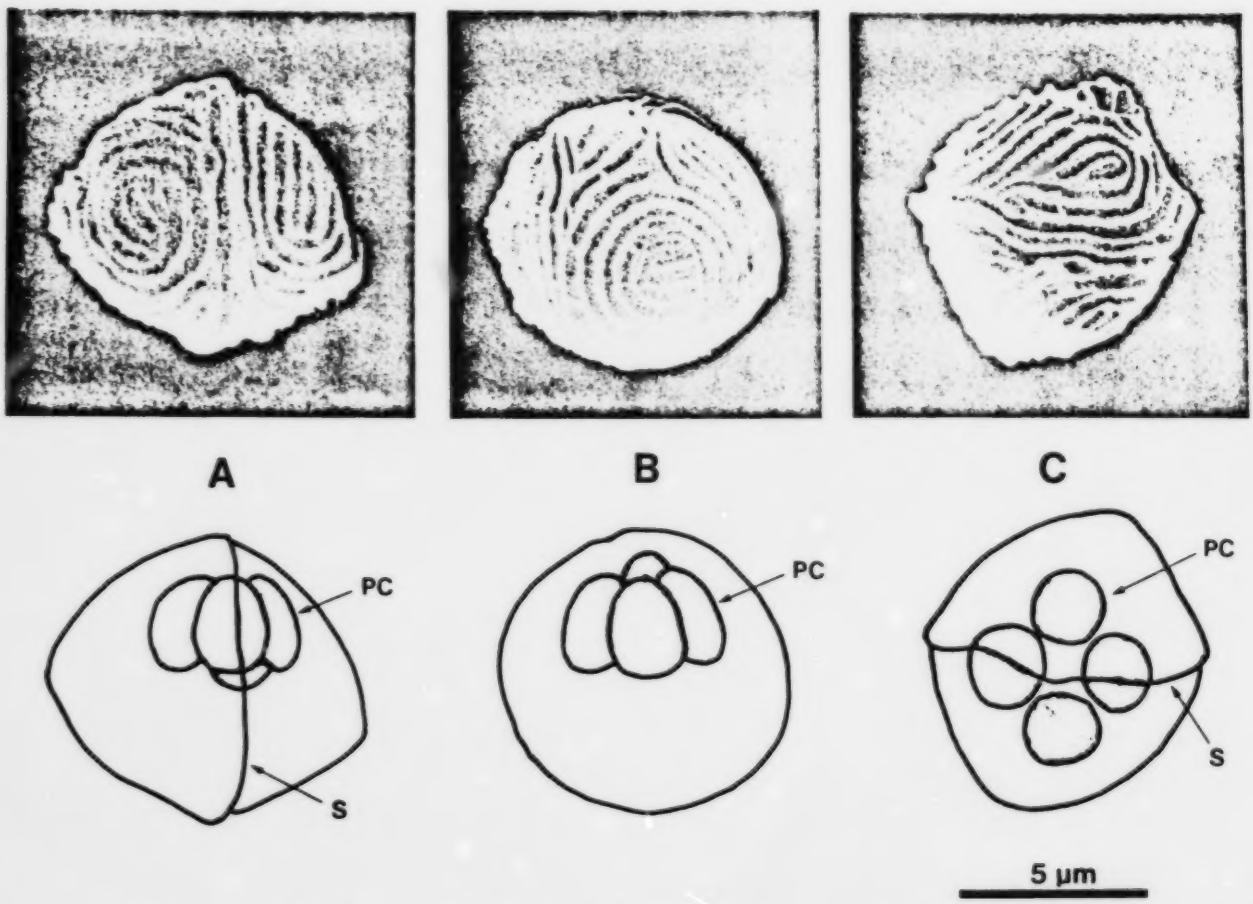


Fig. 2. Spore of *Chloromyxum wardi*. Side (A), frontal (B), and end (C) views. PC, polar capsule; S, suture.

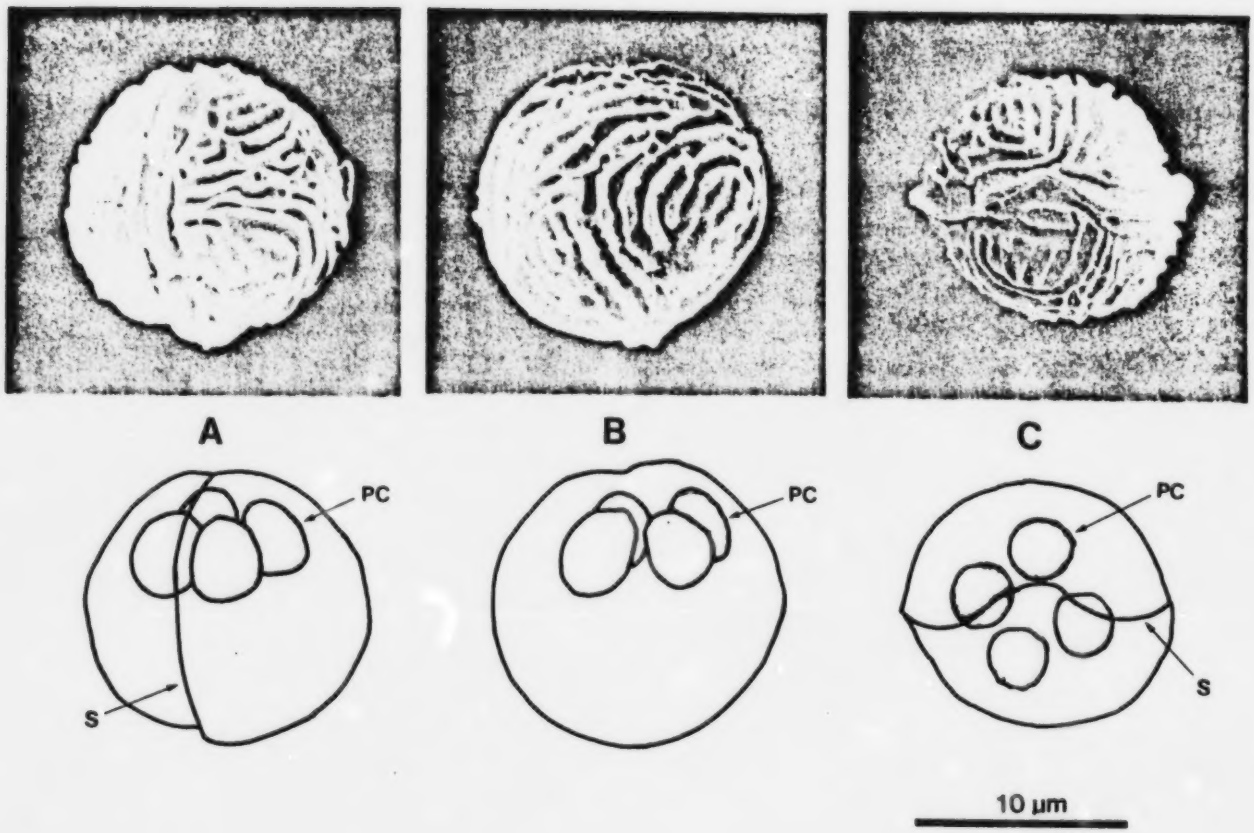


Fig. 3. Spore of *Chloromyxum salvelini*. Side (A), frontal (B), and end (C) views. PC, polar capsule ; S, suture.

Table 1. Prevalence of *Chloromyxum* infection in the various stages of chum salmon.

Locality	Date of catch	Stage of fish	No. of fish examined	Prevalence (%)	
				C. wardi	*C. salvelini*
Chitose River	Apr. 1982	Fry	30	0	0
Inshore areas of Ishikari Bay	Apr. 1982	Fry	65	0	0
North Pacific	May 1982	Pre-mature	40	0	0
Sea of Japan (off Atsuta)	Oct. 1981 & 1982	Maturing	50	0*	0*
Chitose River	Sep.-Nov. 1981 & 1982	Pre-spawning	20	15.0	0
		Spawning	317	59.6	23.7

* The initial stages of trophozites of *Chloromyxum* were found in 4 fish (8%).

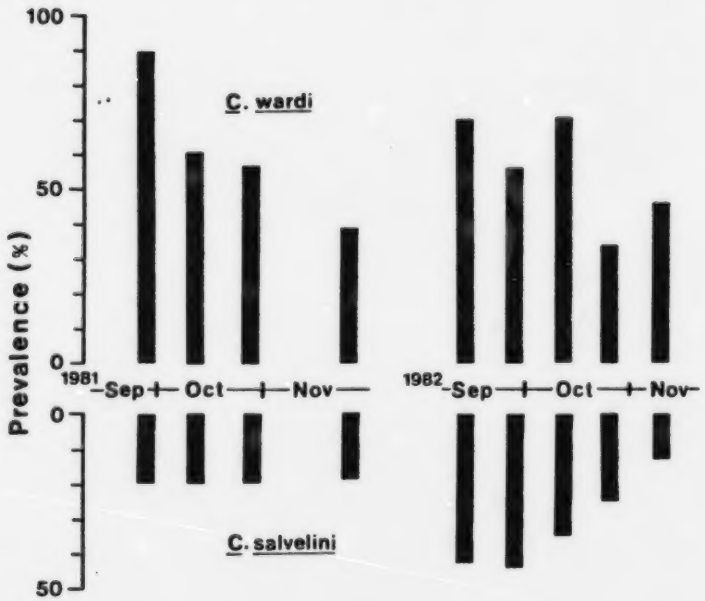


Fig. 4. Seasonal changes in the prevalence of *Chloromyxum wardi* and *C. salvelini* in the gallbladder of spawning chum salmon in the Chitose River.

Table 2. Morphological comparison among the species of the genus *Chloromyxum* recorded from the Pacific salmon (*Oncorhynchus* spp.).

Species	*Chloromyxum wardi* Kudo, 1920		*C. salvelini* Fujita, 1923		*C. chitosense* Fujita, 1923	*C. tanakai* Fujita, 1936
Host	*O. nerka* *O. kisutch*[*1] *O. tshawytscha*[*1]	*O. keta*	*O. masou*[*1]	*O. keta*	*O. keta*	*O. keta*
Location	GB[**]	GB	GB	GB	GB	GB
No. of spores in a trophozite	6~10	5~10	1~2	1~3	1~7	6~8
Spore Length(μm)		7.7~8.8 (8.1±0.4)[***]		11.0~15.8 (12.7±1.5)	8	9.3
Width(μm)	7.5~9[**]	6.9~9.2 (7.8±0.6)	10~13[**]	10.8~15.0 (12.7±1.3)	8	9.3
Thickness (μm)		7.3~8.8 (8.0±0.4)		10.8~15.8 (12.7±1.5)	9	8.5
Polar capsule						
Length(μm)	3	2.3~3.2 (2.7±0.4)	5[**]	3.1~5.4 (4.2±0.6)	4[**]	2.8
Width(μm)	2.5	1.7~3.1 (2.3±0.4)		2.8~3.9 (3.5±0.3)		1.5
Polar filament Length(μm)	?	25.5~51.0 (35.7± 5.8)	20	37.6~72.3 (57.5± 9.8)	15	?
Riges on valve	variable	variable	variable	variable	absent	almost parallel to suture
Caudal filamentous projection	absent	absent	absent	absent	absent	present
Reference	Kudo, 1920	Present authors	Fujita, 1923	Present authors	Fujita, 1923	Fujita, 1936

Species	*C. giganteum* Fujita, 1923	*C. quadriforme* Fujita, 1923	*C. oncorhynchi* Fujita, 1936	*C. orientale* Shulman & Shtein, 1962	*C. majori* Yasutake & Wood, 1957	*C. coregoni* Bauer, 1948
Host	*O. gorbuscha*	*O. masou* *O. keta* *O. gorbuscha*	*O. masou*	*O. masou* *O. keta*[*2] *O. gorbuscha*[*3]	*O. tshawytscha*	*O. nerka*[*1]
Location	GB	GB	GB	GB	Glomeruli	GB
No. of spores in a trophozite	4~5	1~12	10	4~8	?	?
Spore length(μm)	14~16	10	10	10~12		
Width(μm)	13~14	10	9.5	9~10.5	7~8[**]	6~6.5[**]
Thickness (μm)	13~14	12	9.5	9~10.5		
Polar capsule						
Length(μm)	4	5[**]	5[**]	4.5	3.5~4[**]	2.7~2.8[**]
Width(μm)	3			3		
Polar filament Length(μm)	30	25	75	?	?	?
Riges on valve	variable	variable	variable	almost parallel to suture	oblique to suture	parallel to suture
Caudal filamentous projection	absent	absent	absent	absent	absent	absent
Reference	Fujita, 1923	Fujita, 1923	Fujita, 1936	Shulman, 1984	Yasutake & Wood, 1957	Shulman, 1984

[*1] Margolis (1982a) [*2] Vinnichenko et al. (1971) [*3] Konovalov (1971) [**] Gallbladder
[***] (mean ± S. D.) [****] in diameter

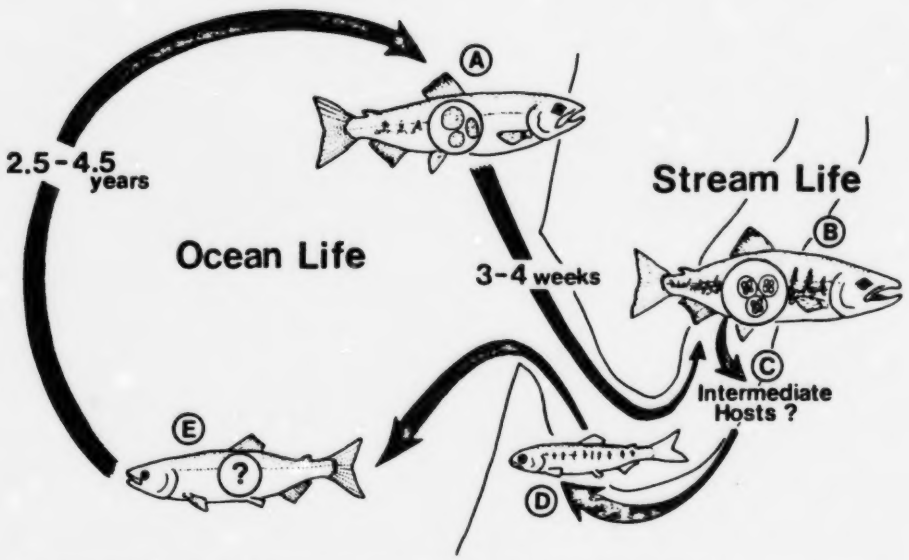


Fig. 5. Proposed life cycle of *Chloromyxum wardi* and *C. salvelini* in chum salmon.
(A) Young trophozoites are present in the gallbladder of maturing chum salmon which migrate into inshore areas near the home river; (B) Mature spores are formed by the time of spawning, and released through the host's intestine into the environment; (C) Spores infect intermediate hosts?; (D) Chum salmon fry become infected during the stream life in the spring; (E) Condition of the parasite in young chum salmon has not been known.

Bibliography

Bashirullah, A. K. M. and J. R. Adams (1983): *Philonema oncorhynchi*: effect of hormones on maturation in anadromous sockeye, *Oncorhynchus nerka*. Int. J. Parasit., 13, 261-265.

Bauer, O. N., V. A. Musselius, and Yu. A. Strelkov (1969): Diseases of pond fishes. Izd. "Kolos", Moskva. (Israel program for scientific translations, Jerusalem. 1973) 220 pp.

Fujita, T. (1923): Studies on Myxosporidia of Japan. J. Coll. Agric., Hokkaido Imp. Univ., 10, 191-248.

藤田経信(1936)：淡水魚に寄生する膠胞子虫の新種に就いて。動雑，48，595-601。

藤田経信(1937)：魚病学　厚生閣　東京　304 pp.

Hiroi, O. (1982): Hatchery approaches in artificial chum salmon enhancement. In C. J. Sindermann (ed.), Proceedings of the eleventh U. S.-Japan meeting on aquaculture, salmon enhancement, Tokyo, Japan, Oct. 19-20, 1982, NOAA Tech. Rep. NMFS, 27, 45-53.

Konovalov, S. M. (1971): Differentiation of local populations of sockeye salmon *Oncorhynchus nerka* (Walbaum). Izd. "Nauka", Leningrad. (English translation by Leda V. Sagan. 1975. Univ. Wash. Publ. Fish., N. S., 6) 290 pp.

Kudo, R. (1920): Studies on Myxosporidia. A synopsis of genera and species of Myxosporidia. Illinois Biol. Monogr., 5, 243-503.

Margolis, L. (1982a): Parasitology of Pacific salmon-an overview. In E. Meerovitch (ed.), Aspects of parasitology. McGill University, Montreal, pp. 135-226.

Margolis, L. (1982b): Pacific salmon and their parasites: a century of study. Bull. Can. Soc. Zool., 13(3), 7-11.

Markiw, M. E. and K. Wolf (1983): *Myxosoma cerebralis* (Myxozoa: Myxosporea) etiologic agent of salmonid whirling disease requires tubificid worm (Annelida: Oligochaeta) in its life cycle. J. Protozool., 30, 561-564.

真山　紘・加藤　守・関　二郎・清水幾太郎(1982)：石狩川産サケの生態－I　1979年春放流稚魚の降海移動と沿岸帯での分布回遊。北海道さけ・ますふ化場研報，36，1-17。

真山　紘・関　二郎・清水幾太郎(1983)：石狩川産サケの生態－II　1980年及び1981年春放流稚魚の降海移動と沿岸帯での分布回遊。北海道さけ・ます化場研報，37，1-22。

Shulman, S. S. (1984): A key for identification of parasites from freshwater fishes of the U. S. S. R. Vol. 1. Protozoan parasites. Izd. "Nauka", Leningrad, 428 pp. (in Russian.)

Shulman, S. S. and G. A. Shtein (1962): Phylum Protozoa. In I. E. Bykovskaya-Pavlovskaya, A. V. Gusev, M. N. Dubinina, N. A. Izyumova, T. S. Smirnova, I. L. Sokolovskaya, G. A. Shtein, S. S. Shulman, V. M. Epshtein (eds.), Key to parasites of freshwater fish of the U. S. S. R. Akad. Nauk USSR, Moscow-Leningrad.(Israel program for scientific translations. 1964) pp. 5-235.

Ueda, H., O. Hiroi, A. Hara, K. Yamauchi, and Y. Nagahama (1984): Changes in serum concentrations of steroid hormones, thyroxine, and vitellogenin during spawning migration of the chum salmon, *Oncorhynchus keta*. Gen. Comp. Endocrinol., 53, 203-211.

Vinnichenko, L. N., V. E. Zaika, V. A. Timofeev, G. A. Shtein, and S. S. Shulman (1971): Parasitic Protozoa from the fishes of the Amur River basin. Parazitol. Sb., 25, 10-40. (In Russian.)

Wolf, K. and M. E. Markiw (1984): Biology contravenes taxonomy in the Myxozoa: new discoveries show alternation of invertebrate and vertebrate hosts. Science, 225, 1449-1452.

Yasutake, W. T. and E. M. Wood (1957): Some Myxosporidia found in Pacific Northwest salmonids. J. Parasitol., 43, 633-642.

Translated bibliographical items

1. Tsunenobu FUJITA (1936): Tansuigyo ni kisei suru nikawa hoshichu no shinshu ni tsuite (New species of myxosporidia parasitizing freshwater fish) Dobutsugaku Zasshi (Zoological Magazine) 48, 595-601.

2. Same author, Gyobyogaku (Fish diseases) Koseikaku Publ. Tokyo, 304 pp.

3. Gen MAYAMA, Mamoru KATO, Jiro SEKI, Ikutaro SHIMIZU (1982): Ishikarigawa-san sake no setai (Ecology of chum salmon from the Ishikari river) - I. 1979 nen haru horyu chigyo no kokai ido no engantai de no bunpu kaiyu (Seaward migration of the fry released in the spring of 1979, distribution and migration in the coastal area), this publication, 36, 1-17.

4. Same authors, minus KATO (1983): Same study - II. 1980 oyobi 1981 nen haru horyuchigyo no kokai ido to engantai de no bunpu kaiyu (Seaward migration, distribution and migration in coastal area of the fry released in the spring of 1980n and 1981), same publication, 37, 1-22.